

IRON MOLDING SANDS IN OHIO.

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There are two classes of molding sands—those for steel castings and those for iron castings. The essential difference between them is the melting point. Thus steel molding sand must have a fusion point of not less than 1,600° C., whereas that for iron castings need not have a melting point of more than 1,300° C. As silica or quartz is the main constituent of all molding sands and is also the chief fusion resisting ingredient, it follows that sand for steel castings must be higher in silica than those for iron castings.* Analyses of steel molding sands from Ohio show a silica range of from 95.66 to 99.43 per cent, whereas the silica content of iron molding sands from this State varies from 77.65 to 83.49 per cent.

DISTRIBUTION OF IRON MOLDING SANDS IN OHIO.

Iron molding sands in Ohio are widely scattered, but at present there are three important centers and three of secondary interest. The first includes the shore of Lake Erie, Muskingum County, and Perry County. Those of secondary interest occur in Gallia, Hamilton, and Butler counties.

MOLDING SANDS ALONG THE LAKE SHORE.

Molding sands along the south shore of Lake Erie are of the mantle rock variety. In other words, they are disintegrated and not obtained by crushing sandstones. They are widely scattered, small in area, less than 10 feet in thickness, and lie on low knolls. Within the past few years such sands have been worked in Erie and Ashtabula counties.

The deposits which are described in the following paragraphs are representative for the area. They do not, however, include all that have been worked within the past few years, nor does it follow that all of those described herein are being exploited at the present time.

Erie County.—The molding sand industry in Erie County began as early at least as 1868 and it is still the most important

*For discussion of steel molding sands of Ohio see this journal, June, 1921.

source along the lake shore. The deposits, which are scattered over all the county except the northwest part, are by far the most important in the eastern half. The northernmost deposit worked is on the Shenk farm, about one-half mile south of the Soldiers' Home, where it lies on a low ridge about 200 feet wide, and is probably an old lake beach. About 12 inches of soil is removed and 30 inches of molding sand secured. The sand has a buff color, is without stratification, and no pebbles were observed. Incipient fusion occurs at $1,300^{\circ}$ C. and complete fusion at $1,424^{\circ}$ C. Its specific gravity is 2.64.

On the J. C. Russell farm, south of Avery, is a deposit of molding sand 6 feet thick at the maximum and located on a low knoll. It is covered by about 8 inches of soil and has been worked for nearly 20 years. The sand has a buff color and is without stratification. The surrounding country is slightly hummocky and doubtless carries sand on the knolls, but the area must be small.

At Parkertown, on the Pennsylvania Railroad, about 8 miles south of Sandusky, approximately 8 feet of molding sand is worked. This differs from most other deposits in the county by the presence of pockets of coarse light-gray sand. The molding sand reaches incipient fusion at $1,327^{\circ}$ C. and complete fusion at $1,436^{\circ}$ C. Its specific gravity is 2.66.

On the H. J. Mason farm, $2\frac{1}{2}$ miles south of Milan, a maximum of $3\frac{1}{2}$ feet of molding sand is secured from a low knoll, which has a width of perhaps 100 yards. The sand has a yellow color and in places is mottled. No stratification was observed, but its texture is said to vary within short distances. The material is loaded on wagons with a ditching machine. Incipient fusion occurs at $1,300^{\circ}$ C. and complete fusion at $1,400^{\circ}$ C. Its specific gravity is 2.67. A large quantity of molding sand is available on this and adjacent farms.

Molding sand has been obtained in the vicinity of Ceylon for more than 15 years. The material, which lies on low knolls and has a maximum thickness of 6 feet, is without stratification, but contains occasional pockets of clay.

Sand from Erie County is used for small or medium-sized castings, such as sewing machines, automobiles, agricultural implements, and marine engines. Much of the material is used in its natural condition, but some is mixed with other sand.

When the strength of the sand needs to be increased, molasses or some other binder is added. The market extends as far west as Detroit and Chicago, east to Cleveland, and south to Columbus and Hamilton.

Sands from this county are very much alike in their physical and chemical properties (see analysis on this page), and in their distribution. As previously stated, they lie on low knolls or ridges and are always thin, the heaviest deposit not exceeding 8 feet. Further, they are unstratified. Of their origin there seems to be no doubt. They are deposits that were laid down on the bed of glacial Lake Erie and were later worked over by the wind and deposited by that agent where now found.

Interesting to report, when the molding sand is removed, the underlying material forms a good soil and is used for the same crops as was the material which overlay it.

COMPOSITION OF MOLDING SANDS, SOUTH SHORE OF LAKE ERIE.

	Silica, SiO ₂	Alu- mina, Al ₂ O ₃	Iron oxide, Fe ₂ O ₃	Titan- ium oxide, TiO ₂	Cal- cium oxide, CaO	Mag- nes- ium oxide, MgO	Igni- tion loss
Mason farm, 2½ miles south of Milan, Erie County.....	79.38	7.96	4.75	.43	1.22	1.09	2.03
Mason farm, 2½ miles south of Milan, Erie County.....	77.65	9.17	4.34	.33	1.14	1.13	2.72
Shenk farm, Soldiers Home, Erie County.....	83.49	8.86	2.11	.33	1.78	1.12	1.32
Russell farm, Parkertown, Erie County.....	82.20	9.24	3.60	.33	1.76	1.13	1.50
Gordon farm, Conneaut, Ashta- bula County.....	79.32	10.08	5.36	.70	1.06	1.21	2.48

Ashtabula County.—Molding sand in this county is confined to the northeast corner, extending west beyond Kingsville and east to the State line and in fact to Springfield, Pa. Nearly all of the deposits lie north of the main ridge road, and hence are near the lake. They are patchy and rather small, measured by acres rather than square miles, and lie on low knolls. A description of the more important deposits follows.

On a knoll on the Hayler farm, northwest of Conneaut and about one-fourth mile from the lake, a deposit 3 feet thick occurs. It is covered with 8 inches of soil, which is removed

by hand labor. The sand has a light yellow color, is unstratified and without pebbles. It is hauled in wagons, loaded directly on cars, and shipped to Erie, Pa.

About 3 miles west of Conneaut on the Gordon farm, a relatively large deposit of molding sand is being worked. Beneath 8 inches of soil lies a maximum of 7 feet of sand which varies somewhat in quality. The upper part is lighter in color and the lower part slightly mottled, and appears more clayey. In places there are thin layers of sand without enough clay to form the necessary bond. About one-fourth mile distant is another deposit which has a maximum thickness of 8 feet.

These deposits are transported by a small locomotive to the New York Central tracks, where the sand is milled and shipped. Milling, however, consists simply of mixing the sands in varying proportions and in this way four grades are secured. The sand from this pit is incipiently fused at $1,336^{\circ}\text{C}$. and completely fused at $1,436^{\circ}\text{C}$. It has a specific gravity of 2.68.

The product has a wide market, as it is shipped to such distant places as Detroit, Chicago, St. Louis, Buffalo, Pittsburgh, and New York.

In its physical and chemical properties, its mode of occurrence, use, and origin, this sand is similar to that in Erie County.

Physical Tests.—Physical tests of molding sand include the transverse and crushing strength, the venting power or permeability to air, the fusion point and the sieve tests. The fusion point has already been given and the sieve tests may be found on page 29. Tests for transverse and crushing strength and venting power were made after the methods of the American Foundrymen's Association.* For transverse strength, blocks of sand one inch square in cross section and four inches between supports were used, whereas for crushing strength the blocks had the same cross section, but the height was $2\frac{1}{2}$ inches. In each case the breaking weight is expressed in pounds. The venting power is the time in minutes necessary to force one gallon of air with a certain pressure through a block of sand one inch thick.

*American Foundrymen's Assoc., Vol. 21, p. 86.

STRENGTH OF LAKE SHORE SANDS IN POUNDS.

	Dry	With 5% Water	With 7½% Water	With 10% Water
<i>Transverse strength:</i>				
Shenk farm, near Soldiers Home.....	.33	.12	.09	.05
Russell farm, near Parkertown, Erie County.....	1.10	.01	.02	.00
Mason farm, south of Milan, Erie County.....	.50	.21	.04	.06
Mason farm, south of Milan, Erie County.....	2.09	.32	.35	.15
Gordon farm, near Conneaut, Ashta- bula County.....	.38	.10	.05	.01
<i>Crushing strength:</i>				
Shenk farm, near Soldiers Home.....	8.05	2.08	.76	.82
Russell farm, near Parkertown, Erie County.....	8.00	.80	.77	.74
Mason farm, south of Milan, Erie County.....	10.14	3.71	.20	1.81
Mason farm, south of Milan, Erie County.....	20.00	5.32	5.76	2.80
Gordon farm, near Conneaut, Ashta- bula County.....	2.91	2.76	.77	.69

VENTING POWER OR PERMEABILITY TO AIR OF LAKE SHORE SANDS.

	Dry	With 5% Water	With 7½% Water	With 10% Water
Shenk farm, near Soldiers Home.....	.42	.67	.72	.48
Russell farm, near Parkertown, Erie County.....	.17	.45	.30	.43
Mason farm, south of Milan, Erie County	.50	.95	1.92	.55
Mason farm, south of Milan, Erie County	.50	1.05	1.25	.50
Gordon farm, near Conneaut, Ashtabula County.....	.42	.53	.47	.58

MOLDING SANDS IN MUSKINGUM COUNTY.*

Muskingum County is the most important source of iron molding sands in Ohio and one of the largest sources in the United States. Although the principal deposits are in the vicinity of Zanesville, they extend north to Dresden, east to Sonora, and southeast to Duncan Falls. In altitude the sands present marked variations—from 700 feet above sea level on the flood plain of the Muskingum River to 900 feet on top of the adjacent hills.

*For a detailed account of the molding sands of Muskingum County see Geol. Surv. of Ohio, Bull. 21, Chap. 7.

The largest known deposit of molding sand in the county lies on the northern half of South Zanesville hill at an elevation of 900 feet. No complete section of these deposits was seen but an employee who has worked on the hill for 15 or more years gave the following succession:

Soil.....	2 ft.
Brown sand, No. 3. No pebbles.....	8
Brown sand, No. 1. Finer than the above.....	4
Coarse gray sand, with many sandstone fragments, but no foreign pebbles.....	15
Coarse, sharp sand without sandstone fragments.....	8
Shale, reported.	

All this material, except soil at top and shale at base, has been used for molding purposes. The two sands below the soil are similar except for fineness of grain and this doubtless varies horizontally. Surfaces exposed to weathering show stratification, but fresh surfaces do not. These sands are marketed without milling; by mixing them various grades may be secured. Both sands are considered a wind deposit, which is indicated by fineness of grain, absence of pebbles or coarse fragments of rock, lack of foreign material, and by their altitude of 900 feet, or 200 feet above the valley.

The coarse gray sand which occurs next in descending order contains fragments of shaly sandstone with a maximum length of 4 or 5 inches and a thickness that rarely attains one-half inch. They are not evenly distributed, but in places occur in pockets and there may form the larger part of the mass. The fragments very closely resemble the coarse shaly sandstone that is found in the surrounding country, from which it doubtless originated. This material, sand and shaly sandstone, is hauled to the mill where it is crushed, screened, and then marketed as No. 3 sand. It is the only hilltop deposit of this type that has been found in the county; moreover its area is small, about 600 feet north-south and 200 feet east-west. Doubtless it was the work of running water before the present topography was developed, and its source was the sandy shale or thin-bedded sandstone of the surrounding country.

Microscopic examination of this variety was made by Prof. W. J. McCaughey, who listed the following minerals in order of their abundance.

- | | |
|----------------|----------------|
| 1. Quartz. | 6. Magnetite. |
| 2. Orthoclase. | 7. Calcite. |
| 3. Microcline. | 8. Hornblende. |
| 4. Muscovite. | 9. Tourmaline. |
| 5. Biotite. | 10. Garnet. |

Chemical analysis of this sand gave Prof. D. J. Demorest the following results:

Silica, SiO_2	80.66 per cent
Alumina, Al_2O_3	6.56
Ferric oxide, Fe_2O_3	5.34
Titanic oxide, TiO_260
Lime, CaO	1.00
Moisture at 105°C	1.27
Ignition loss.....	2.53

At the east end of the South Zanesville hill is a pit where the following section was measured:

Soil.....	1 ft.
Fine sand, unstratified, mottled, no pebbles.....	11
Shaley sandstone, rotten.....	3
Sandstone, rotten.....	1

The whole section, soil excepted, is worked. The rotten shale and sandstone are distinctly stratified and are without doubt in place, that is, have not been transported from some other location.

Molding sand has been obtained at several other places on the west side of the Muskingum River. Among these may be mentioned the flood plain of this river just below the tube works, at an altitude of 700 feet; top of Putnam Hill at an elevation of 900 feet; near Drake Station, where the sand lies about 820 feet above sea level, is stratified, contains small pebbles, and is therefore considered a water deposit. This material is crushed in a dry pan and then screened. About one mile north of Ellis the sand occurs at an elevation of 850 feet, is without stratification, and free from pebbles. It is fine grained and may be classed as No. 1. Near Dresden are two or three deposits which have been worked in recent years. The material varies in texture from coarse to fine and in places shows stratification. An occasional pebble or rock fragment was found and the sand is therefore considered a water deposit. A sample from the pit of the Central Ohio Sand and Gravel Co., one-half mile south of Dresden, was analyzed by Prof. Demorest, with the following results:

Silica, SiO_2	83.25 per cent
Alumina, Al_2O_3	8.11
Ferric oxide, Fe_2O_3	3.14
Titanic oxide, TiO_230
Lime, CaO40
Magnesia, MgO54
Ignition loss.....	4.28

MOLDING SANDS EAST OF THE MUSKINGUM RIVER.

One of the largest deposits of molding sand in Muskingum County lies at an altitude of 900 feet on a hill in the northeastern part of Zanesville. The following section was measured in this pit in 1917:

	Soil and clay.....	2½ ft.
4.	Fine sand.....	4
3.	Red sand.....	4
2.	Coarse sand.....	2
1.	Fine sand.....	10
	Clay unmeasured.	

The basal sand is marketed as No. 0 and No. 1; it is used for brass and for small iron castings. Sand 2 of the section is not commonly used alone, but is mixed with 3 and 4 and then makes No. 2 and 3 sands. Sand 3 was not marketed alone when the pit was visited, but was mixed with other sands. Sand 4 was mixed with 2 to form a No. 2 sand.

The silica range of sands from this pit, according to Prof. Demorest, is from 81.76 per cent to 85.99; alumina from 5.24 to 8.26; and iron oxide from 2.94 to 4.20.

Sands similar to those just described have been worked directly across the river from the American Rolling Mill Co. at an altitude of 800 feet.

Near the eastern limit of Zanesville are numerous deposits of molding sand. One of these, opened about 35 years ago, measures approximately 30 feet in thickness. It consists of sand and clay, the latter measuring as much as 10 feet in depth. The sand is distinctly stratified and carries many pebbles, some of which measure 4 inches in diameter. The sand and clay are ground together and then screened. By mixing the materials in varying proportion several varieties of sand are secured.

At the station Oakland is another deposit and, like the preceding one, it lies about 820 feet above sea level. When visited it had a maximum thickness of 15 feet, contained many small pebbles, and was distinctly stratified. Near-by is a ledge of about 12 feet of coarse sandstone, which is ground with the sand. On top of the knoll is a thin bed of brown sand, without pebbles or stratification. By mixing these deposits, as many as 14 varieties of molding sand are reported to have been produced.

Molding sands exist southeast of Zanesville and have been worked near Lawton and Pierce. A smaller deposit occurs a mile north of Duncan Falls.

MOLDING SANDS IN PERRY COUNTY.

The one important center for molding sand in Perry County is in the valley of Rush Creek and the deposits now worked extend from about 1 mile to perhaps 3 miles east of New Lexington.

The materials which form the basis of the industry are sandy loam and rotten sandstone. The sandy loam was formed by the disintegration of sandstone or sandy shale and it gradates into the underlying rotten sandstone. Above the loam is 1 to 2 feet of soil, which is rejected. These materials lie above the No. 6 or Middle Kittanning coal, and hence near the top of the Allegheny formation.

The plant of the New Lexington Sand Co., which lies about one mile east of New Lexington, was opened in 1904 and is the pioneer plant of the district. Following is a section in the pit:

Soil.....	1 ft.
Sandy loam (binder).....	5
Rotten sandstone.....	12

The rotten sandstone, which is coarse grained, thin bedded, and carries numerous flakes of white mica, contains some iron, and has a yellow color. The company owns 100 acres of good rock, so that its supply of raw material is very large.

The materials from this pit are run through a disintegrator and thus reduced to coarse sand, when it is ready for shipment. Two grades are made by mixing the rotten sandstone and binder in different proportions. In one there are approximately two parts of sandstone to one of binder, whereas in the finer variety these proportions are reversed. This sand softened at 1,345° C. and liquified at 1,436° C. Its specific gravity is 2.64.

An analysis of the finer sand (one part sandstone to two parts of binder) from this plant was made by Prof. D. J. Demorest with the following result:

Silica, SiO ₂	82.17 per cent
Alumina, Al ₂ O ₃	8.77
Iron oxide, Fe ₂ O ₃	4.44
Titanium oxide, TiO ₂55
Calcium oxide, CaO.....	.50
Magnesium oxide, MgO.....	.79
Ignition loss.....	3.07

Prof. Wm. J. McCaughey made a microscopic examination of this sand and reported the following minerals which are listed in order of their abundance:

- | | |
|----------------|----------------|
| 1. Quartz. | 5. Biotite. |
| 2. Orthoclase. | 6. Tourmaline. |
| 3. Microcline. | 7. Zircon. |
| 4. Muscovite. | 8. Magnetite. |

Quartz and feldspars are the essential minerals, but hornblende and biotite are important accessories. Other minerals are found only in small proportions.

Just east of the New Lexington sand plant is that of the Superior Sand Co., which works about 20 feet of rock, the upper 3 feet more or less being a sandy loam used as binder and the lower 17 feet a coarse-grained rotten sandstone. The material is loaded on cars by a planer which does the work of 10 men. The base of the pit is about 20 feet above the Middle Kittanning or No. 6 coal.

Approximately one-half mile farther east is the plant of the Lancaster Coal and Sand Co., which works about 18 feet of rotten sandstone covered with 3 feet more or less of loam and soil. The deposit lies about 20 feet above the Middle Kittanning or No. 6 coal. It is worked with a steam shovel and run through a disintegrator. Shipments were first made in 1919.

On the north side of the valley is the plant of the Ayers Mineral Co., which works the rock to a maximum depth of 26 feet, but it is so variable in texture that in places only a few feet is satisfactory. The rock is cut and loaded by a planer and is then run through a disintegrator and shipped.

The plant of the Jones Sand Co., also on the north side of the valley, at Goston, is the easternmost in the field. A section taken in the pit follows:

Soil.....	8 inches
Sandy loam (binder).....	4-5 feet
Rotten sandstone.....	8-9 feet

This plant is unique in that bond and sand are mined separately; whereas the usual practice is to mine them together so that the proportion of sand and bond is not controlled except in a very crude way. By separate mining the two constituents may be mixed in any desired proportion. Thus one large customer calls for 10 parts of sand to 1 of bond, while another asks for the proportion of 5 to 4.

The materials are loaded on cars with a steam shovel and then hauled to a mill where they are run through a disintegrator. This sand softened at 1,345° C. and liquified at 1,478° C. Its specific gravity was 2.64.

A sample of No. 5 sand from this plant was analyzed by Prof. D. J. Demorest with the following result:

Silica, SiO ₂	82.06 per cent
Alumina, Al ₂ O ₃	8.01
Iron oxide, Fe ₂ O ₃	3.70
Titanium oxide, TiO ₂35
Calcium oxide, CaO.....	.56
Magnesium oxide, MgO.....	.96
Ignition loss.....	2.72

The same grade of sand was examined microscopically by Prof. Wm. J. McCaughey, who reports the following minerals which are listed in the order of their abundance:

1. Quartz.

2. Orthoclase.

3. Muscovite.

4. Microcline.

9. Epidote.
5. Biotite.

6. Magnetite.

7. Hornblende.

8. Albite.

Quartz and orthoclase comprise the mass of the sand. Muscovite is common, but most of the other minerals listed are found only occasionally.

STRENGTH OF PERRY COUNTY MOLDING SANDS IN POUNDS.

	Dry	With 5% Water	With 7½% Water	With 10% Water
<i>Transverse Strength:</i>				
No. 5 Sand, New Lexington Sand Co...	3.88	.48	.73	.39
No. 5 Sand, Jones Sand Co., Goston...	4.85	.62	.52	.12
<i>Crushing Strength:</i>				
No. 5 Sand, New Lexington Sand Co...	46.65	10.37	10.60	8.21
No. 5 Sand, Jones Sand Co., Goston...	51.00	8.66	7.72	3.36

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No. 5 Sand, New Lexington Sand Co.....	2.30	2.42	2.05	1.67
No. 5 Sand, Jones Sand Co., Goston.....	.50	.95	.55	.37

MOLDING SANDS IN GALLIA COUNTY.

Molding sands are being developed along the Hocking Valley Railway in Gallia County from Mills Station to the vicinity of Bidwell, a distance of about 6 miles.

When visited in September, 1921, the southernmost sand pit was on the Humphrey farm in the northern part of Section 12, Green Township. The deposit is lens shaped with a maximum thickness of 14 feet and is covered with approximately 18 inches of stripping. Its altitude is 660 feet above tide.

The sand has a light brown color. It appears very largely unstratified, especially in the upper part, but near the base distinct layers were observed in one or two places. Stratified sand was reported below the base of the pit and with a thickness of 4 feet, but it is not mined as it is unsuitable for molding purposes. It is said to have various colors, some of it light gray. In texture the sand is finest in its higher parts and distinctly coarser below. Black streaks were noted in places and sandy concretions were found, but these appeared to be of secondary origin. Pebbles were neither seen nor reported. The sand is hauled in trucks to the Hocking Valley Railway, $1\frac{1}{2}$ miles distant, and shipped without milling to Michigan, Indiana, and Illinois, as well as various places in Ohio. It is used for small castings and especially in automobile work.

The largest sand pit in Gallia County is at Kerr, on the Hocking Valley Railway. The pit is about 660 feet above sea level, and 6 acres are estimated to have been worked over. The deposit is lens shaped and it has a maximum thickness of 16 feet.

The color is the usual shade of brown and is similar to that on the Humphrey farm and elsewhere in Gallia County. The material is finest in texture near the top; below it is distinctly sandy in places. When a fresh surface is exposed there is little or no evidence of stratification, but on weathering layers become distinct. Numerous sandstone pebbles were noted, but they can be crushed easily between the fingers and hence probably are of secondary origin.

The sand is loaded on cars with a steam shovel and hauled by gravity to a mill where it is run through a disintegrator. It is then marketed at Detroit, Chicago, and Indianapolis, as well as in numerous Ohio cities. The sand is classed as No. 4 and is reported to be one grade coarser than that from the Humphrey farm. It is too coarse for fine castings and is used for automobile cylinders, blocks, car wheels, machine frames, etc. When working to capacity the plant is reported to produce 250 tons of sand per day.

Origin of Gallia County Moulding Sands

Mr. J. M. Weed, County Surveyor, has plotted on topographic maps the locations of all the molding sand deposits that have been worked in Gallia County and they lie pretty uniformly 660 feet above sea level. A second characteristic is their stratification, though this is not evident in most places unless the bluff has been exposed to weathering. A third factor is the similarity in color, texture, and other physical properties of the several deposits. A fourth point is their location in a preglacial valley whose waters flowed north and hence were dammed or ponded by the great continental ice sheet.

From this evidence it appears that the sands under consideration are of glacial origin, that they were carried from the ice by glacial streams and deposited in the broad valleys which were at that time occupied by long, narrow lakes. When the ice withdrew, the waters of the lakes had found an outlet to the south and the lakes were slowly emptied. Probably at that time these silts covered the valley floor, but most of them were removed by subsequent erosion.

CINCINNATI AND VICINITY.

Molding sand has been shipped from Delhi at the extreme western edge of Cincinnati since about the year 1889. Some of the deposits lie at or near the foot of the river front hills, others on the slopes, and others still on the summits of these hills at an elevation of 800 feet. The deposits are small and patchy, and are reported to be restricted to the river front hills between Muddy Creek and Goose Creek.

The deposits are of two distinct types—one is fine and loam-like and the other contains pebbles. All deposits are lens shaped and the areas are small.

The fine loam-like material has a maximum thickness of about 7 feet. It lacks stratification, has a yellow color when dry and a tendency to stand with steep slopes. In places vertical cracks were noted and these gave the mass the appearance of blocks standing on end. This material is used for fine castings and is marketed as No. 1, No. 2 and No. 3 sands. In a pit on the land of Jacob Fliehman in the Ohio Valley, the No. 1 sand lay at the base and the No. 3 sand at the top, with the No. 2 between. The different grades, however, are much alike in texture as well as in other respects. The sand is not milled.

The coarse pebbly material was noted only on the tops of the river front hills. It has a yellow color when dry, but a darker shade than that of the fine material at the surface. The pebbles are numerous but small, the largest seen not exceeding 3 inches in diameter. Many of them are well rounded and all appeared weathered. The pebbles are of the common types—igneous, sedimentary, and metamorphic. On exposure faint stratification was observed in one place, but this was not where the pebbles were most abundant. The maximum thickness observed of this pebbly material is about 18 feet. It is used at Cincinnati and other places for large castings. A section on top of a hill on land of Jacob W. Fliehm follows:

Fine sand, No. 1.....	5 ft.
Light-gray sandy clay, rejected.....	1
Pebbly sand, No. 4.....	12
More pebbly sand, No. 5.....	5

The light gray material between the pebbly sand and the fine material at the top is unsuitable for molding purposes and has to be rejected. It forms a thin layer, not more than one foot in thickness and appears to be persistent. It resembles the "white clays" of southwest Ohio and may be their counterpart.

The origin of these molding sands appears to be clear enough. The fine material has been transported and deposited by the wind, while the pebbly material is of glacial origin. The latter is much the older and was laid down during Illinoian glacial time, long before the glacial deposits in central and northern Ohio. After the pebbly material was deposited the white clays were laid down on them and still later they in turn were buried beneath the fine yellow sands.

About one mile up the Ohio Valley from North Bend and on top of a river-front hill at an altitude of about 740 feet is a deposit of molding sand that has been worked in an irregular way for more than 28 years. The material closely resembles the pebbly variety found at Delhi, but the proportion of pebbles varies greatly and in places they are rare. Occasional pockets of stratified sand were observed in the pebbly material. The maximum thickness of the deposit that has been worked is reported to be 20 feet. The origin of the deposit is similar to that of the pebbly material at Delhi. The pipe works at Addyston, about one mile distant, has been the principal market for this molding sand.

A third source of molding sand in the Cincinnati district is at the village of Cleves, about one mile north of North Bend. The deposit is at an altitude of about 640 feet and hence does not lie at the summit of the upland, which here is about 800 feet above sea level.

The sand exposed in the pits has a maximum thickness of perhaps 30 feet. The top 6 to 8 feet is a loam and below this is a large deposit of coarse, sharp, gray sand that is distinctly stratified. This sand by itself lacks binder and hence does not make a molding sand. Mixed with the loam at the top, however, it has adequate strength and is well suited for castings. These pits were opened about 1917.

The loam at the top is similar to the fine material at Delhi and appears to have had a similar origin. The underlying sharp, gray sand looks very much like a water deposit (it faces the Miami River), but it may have been transported and deposited by the wind.

MOLDING SANDS IN BUTLER COUNTY.

The molding sand of Butler County lies about one and one-half miles northeast of Overpeck, or approximately 6 miles from Hamilton. Following is a section taken in the pit of the Buckeye Molding Sand Co., on the John Letschke farm:

Soil.....	1 ft.
Molding sand.....	3
Sharp sand.....	10-15

The molding sand, which varies in thickness from 2 to 4 feet, has a brown color and is without stratification. Pebbles up to one inch in diameter are common. The material is used in the foundry at Overpeck, and also trucked to Hamilton, where much of it is shipped by rail to Cincinnati, Columbus, Cleveland, and several places in Indiana. The material is not milled. It is used for gray iron castings, which weigh from 100 pounds to 40 tons.

The deposit lies in the angle between Four Mile Creek and the Miami River at an elevation of 640 feet. It is a silt that was deposited by those streams when the territory was a flood plain. The Buckeye Company has a lease on 40 acres and has worked the deposit approximately 10 years. Sand of like quality is now worked on an adjacent farm. Similar material is reported to have been gotten near Four Mile Creek about 30 years ago.

MOLDING SAND SCREEN TESTS.

	Over 10 mesh	Between 10 and 20 mesh	Between 20 and 30 mesh	Between 30 and 40 mesh	Between 40 and 50 mesh	Between 50 and 60 mesh	Between 60 and 80 mesh	Between 80 and 100 mesh	Over 100 mesh	Average Fineness
Sand from Shenk farm near Soldiers Home, Erie County.....	.13	.20	.22	.29	.39	.51	2.33	.86	95.07	97.72
Sand from Mason farm, 2½ miles south of Milan, Erie County.....	.15	1.05	2.27	7.62	9.54	10.12	19.51	2.53	47.21	72.66
Sand from Mason farm, 2½ miles south of Milan, Erie County.....	.07	1.18	3.83	7.82	12.92	10.32	18.21	1.33	44.32	69.87
Sand from Russell farm, Parkertown, Erie County.....	.00	.12	.23	.36	.97	1.23	4.46	1.28	91.35	96.22
Sand from Gordon farm, Conneaut, Ashtabula County.....	.35	.69	.82	.57	.61	.67	1.51	.85	93.93	96.50
Ayers Mineral Co. No. 3 Sand, South Zanesville, Muskingum County.....	1.68	2.61	5.23	39.26	.01	12.05	11.29	.72	27.15	53.61
Central Ohio Sand & Gravel Co. No. 2 Sand, near Dresden, Muskingum Co. .	.03	.18	1.30	4.57	4.42	4.47	7.58	1.53	75.92	87.34
Zanesville Sand Co. No. 1 Sand, Zanes- ville, Muskingum County.....	.00	.02	.11	.09	.26	.12	1.13	.11	98.16	99.14
Zanesville Sand Co. No. 2 Sand, Zanes- ville, Muskingum County.....	.00	.01	.04	.51	5.62	11.95	23.62	5.77	52.48	79.65
Zanesville Sand Co. No. 3 Sand, Zanes- ville, Muskingum County.....	.00	.02	.11	1.37	5.17	13.37	22.70	5.98	51.28	78.87
New Lexington Sand Co. No. 5 Sand, New Lexington, Perry County.....	.49	.99	8.52	30.21	20.78	7.23	7.76	.66	23.36	51.34
Jones Bros. Sand Co. No. 5 Sand, Goston, Perry County.....	.02	2.02	33.25	33.34	12.33	3.84	3.62	.21	11.37	37.42